

EOSAEL92

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LASER TRANSMITTANCE MODULE
LZTRAN

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ABSTRACT

The laser transmission (**LZTRAN**) module calculates molecular absorption coefficients and transmittances for 97 specific laser frequencies ranging from the visible to the far infrared ($0.6\mu\text{m}$ to $11.0\mu\text{m}$). Absorption coefficients and transmittances may be calculated for horizontal or slant paths between sea level and 5.0 km. The user may specify one of six model atmospheres or input his own atmosphere.

Continuum absorptions due to H_2O and N_2 are now calculated in the **LZTRAN** subroutine **LZCONT** and are not included in the calculated molecular absorption coefficients.

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Chapter 1

TECHNICAL DOCUMENTATION

1.1 Introduction

For high visibilities in the earth's lower atmosphere, extinction is due primarily to water vapor and six different molecules. This molecular absorption is often the result of a combination of line center, line wing, and continuum mechanisms from one or more of these molecules. By using a polynomial expression, LZ-TRAN calculates the absorption coefficients as functions of pressure, temperature, and water vapor pressure for 97 frequencies. The coefficients for the polynomial have been determined from least-squares analysis on absorption coefficient data generated by a modified version of the atmospheric transmittance code ATRANX. [Miller and et al, 1978]

1.2 Availability

EOSAEL92 is available to U.S. Government Agencies, specified allied organizations, and their authorized contractors at no cost. U.S. Government agencies needing EOSAEL92 should send a letter of request, signed by a branch chief or division director, to US Army Research Laboratory ARL. Contractors should have their Government contract monitor send the letter of request. Allied organizations must request EOSAEL92 through their national representative.

Please include, within security restrictions, your intended use(s). Also, indicate what type of nine-track tape your computer can read. We can make "ASCII" tapes, and UNIX "tar" format tapes in either 1600 or 6250 bpi. We can also make SUN cartridge tapes We can't supply EOSAEL92 on other media. Documentation for the modules is included.

The EOSAEL92 point of contact at ARL is Dr. Alan Wetmore.

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1.3 Description of the LZTRAN Algorithm

The LZTRAN module has been substantially rewritten for EOSAEL92. The major revision is that LZTRAN can now calculate slant path transmittances through atmosphere of changing pressure, temperature, and partial pressure of water vapor. The module also now tests for water vapor saturation, thereby disallowing unrealistic clear air scenarios. In addition, the continuum absorptions of N₂ and H₂O are now computed in the LZTRAN module and are not included in the polynomial coefficients as they were in previous LZTRAN versions. This feature allows the user to replace the currently used LZTRAN continuum expressions through modification of the subroutine LZCONT. Finally, LZTRAN offers the user six model atmospheres to establish the temperature, pressure, and the partial pressure of water vapor vertical structures as well as the option to enter a user-defined atmosphere.

The focal point of the module is the polynomial that computes the molecular absorption coefficients (in kilometers⁻¹) for specified values of pressure, temperature, and the partial pressure of water vapor. (Equation 1.2 displays the polynomial used in LZTRAN.) For horizontal paths, the pressure, temperature, and partial pressure of water vapor are assumed constant and the earth is considered flat. For slant paths, the atmosphere, again assumed plane-parallel, is segmented into layers. The pressure, temperature, and partial pressure of water vapor for the midpoint in each layer are calculated from the selected model atmosphere profiles. These midpoint values are assumed constant throughout their respective layers. The path length through each layer is given by

$$PL = Z / \cos \theta \quad (1.1)$$

where

PL = path length,
 Z = layer thickness (vertical), and
 θ = zenith angle of the line of sight (LOS)

The maximum allowable layer thickness is 500 m, and inputs requesting thicker layers will be defaulted to this value. After the atmosphere between the laser and target has been segmented into layers of equal thickness, a transmittance, T_1 , is calculated for the entire LOS. The code then doubles the number of layers by halving the thickness of the layers and calculates a second transmittance, T_2 . If $|T_1 - T_2| \leq 0.01$, then the module terminates, printing the results of the T_2 calculations. If $|T_1 - T_2| > 0.01$, then the layers are again divided by 2 and a transmittance, T_3 , is computed. This binary procedure continues until $|T_j - T_{j+1}| < 0.01$.

The following sections provide additional details concerning the molecular absorption coefficients, model atmospheres, and the H₂O and N₂ continuum algorithms.

1.4 Generation of Absorption Coefficients

The code ATRANX was used to calculate the molecular absorption coefficients for all addressable frequencies in LZTRAN. This code has been verified by Lui and Pierluissi,[Lui and Pierluzzi, 1978] who found good agreement in most spectral regions with the code HITRAN. Miller[Miller and et al, 1983] has compared ATRANX calculations with those of FASTCODE and also found satisfactory agreement.

The Air Force Geophysics Laboratory (AFGL) 180 line parameter compilation tape[Rothman, 1981] was used for the line-by-line calculations, and Lorentz profiles were assumed for all molecular line shapes. The gases included in the computations are CO, CO₂, O₂, O₃, CH₄, and N₂. The number density of ozone is

quite variable from the surface to 5 km. However, since the mean value remains reasonably constant, a value of $5.4 \text{ by } 10^{-5} \text{ g/m}^3$ (US Standard Atmosphere) was used for all atmospheric scenarios.

No continuum absorption was considered in making the ATRANX calculations, although Rayleigh scattering, when appropriate, was added to the molecular absorption coefficients.

A matrix of 54 absorption coefficients was computed as a function of pressure (1013, 800, and 500 millibar), temperature (240, 290, and 320 K), and partial pressure of water vapor (6 values) for each laser frequency listed in table 1.1. After the matrix was completed, a least squares fit with the following polynomial was made.

$$k = \alpha_0 + \alpha_1 T + \alpha_2 P + \alpha_3 T^2 + \alpha_4 P^2 + \alpha_5 TP + \alpha_6 P^{-1} + \alpha_7 W + \alpha_8 TW + \alpha_9 PW + \alpha_{10} TW^2 + \alpha_{11} PW^2 + \alpha_{12} W^2 + \alpha_{13} T^2 W^2 + \alpha_{14} T^2 W \quad (1.2)$$

where

T = temperature (degrees)

P = total pressure (millibars)

W = water vapor partial pressure (millibars)

The derived coefficients, α_0 through α_{14} , are found in the **COEFF** subroutine data statements. There are certainly many frequencies for which the above polynomial is overkill; however, to facilitate the coding of LZTRAN and to reduce the interaction required in processing the data, a single polynomial was selected. This polynomial expression was constructed to provide a “best fit” to the calculated absorption coefficients in general and is only roughly based on theoretical expectations.

1.4.1 The New Laser Lines

The new laser lines: Cu Vapor 0.578, Ruby 0.694, Alexandrite 0.755 & 0.790, Nd-YAG 1.318, 1.319, 1.338 & 1.358, HF 2.673, and He-Ne 3.392, were calculated using FASCODE2 for the same 54 combinations of temperature, pressure, and relative humidity. However, a different polynomial was used:

$$k = \alpha_0 + \alpha_1 T + \alpha_2 P + \alpha_3 W + \alpha_4 TP + \alpha_5 TW + \alpha_6 PW + \alpha_7 T^2 + \alpha_8 P^2 + \alpha_9 W^2 + \alpha_{10}(1/P) + \alpha_{11} TW^2 + \alpha_{12} PW^2 + \alpha_{13} T^2 W^2 + \alpha_{14} T^2 W \quad (1.3)$$

$$+ \alpha_{15} W^3 + \alpha_{16} T^2 P + \alpha_{17} TP^2 + \alpha_{18} T^2 P^2 + \alpha_{19} P^2 W^2 + \alpha_{20} P^2 W \quad (1.4)$$

$$+ \alpha_{21}(1/P^2) + \alpha_{22} T^3 + \alpha_{23} P^3 + \alpha_{24} TW^3 + \alpha_{25} PW^3 + \alpha_{26} WP/T \quad (1.5)$$

Table 1.1: Laser Lines Available in LZTRAN

Laser ID	Line ID	λ μm	ν (1/cm)	Laser ID	Line ID	λ μm	ν (1/cm)
CU		0.578		MISC		3.4000	2941.177
KR ⁺	Kr ⁺ .64	0.6471	15453.563	DF	P1(3)	3.5214	2839.779
MISC		0.6930	14430.014	DF	P1(4)	3.5507	2816.346
RU		0.694	17301.038	MISC		3.5700	2801.121
ALX	Alx .71	0.7100	14084.508	DF	P1(5)	3.5811	2792.438
ALX	Alx .73	0.7300	13698.631	DF	P1(6)	3.6128	2767.936
ALX	Alx .74	0.7400	13513.514	DF	P2(3)	3.6363	2750.048
ALX	Alx .75	0.7500	13333.332	DF	P1(7)	3.6456	2743.033
KR ⁺	Kr ⁺ .75	0.7525	13289.037	DF	P2(4)	3.6665	2727.397
ALX	Alx .76	0.755	14409.222	DF	R5(11)	3.6698	2724.944
ALX	Alx .79	0.790	13245.033	DF	P1(8)	3.6798	2717.539
MISC		0.8300	12048.193	DF	P2(5)	3.6983	2703.945
GAAS	Ga .850	0.8500	11764.707	DF	P1(9)	3.7155	2691.428
GAAS	Ga .875	0.8750	11428.570	MISC		3.7300	2680.965
GAAS	Ga .900	0.9000	11111.111	DF	P2(6)	3.7310	2680.247
GAAS	Ga .925	0.9250	10810.811	DF	P1(10)	3.7521	2665.174
GAAS	Ga .950	0.9500	10526.316	DF	P3(3)	3.7563	2662.194
MISC		1.0300	9708.736	DF	P2(7)	3.7651	2655.972
MISC		1.0600	9433.961	DF	P3(4)	3.7878	2640.055
ND-YAG		1.318	7587.253	DF	P1(11)	3.7902	2638.383
ND-YAG		1.319	7581.501	MISC		3.8000	2631.579
ND-YAG		1.338	7473.842	DF	P2(8)	3.8007	2631.094
ND-YAG		1.358	7363.770	DF	P3(5)	3.8206	2617.390
MISC		1.5400	6493.506	DF	P1(12)	3.8298	2611.103
MISC		2.4000	4166.667	DF	P2(9)	3.8375	2605.863
HF		2.673	3741.115	DF	P3(6)	3.8547	2594.236
MISC		2.9000	3448.276	DF	P1(13)	3.8707	2583.512
HE-NE		3.392	2948.113	DF	P2(10)	3.8757	2580.179

Table 1.1: Laser Lines Available in LZTRAN (cont)

Laser ID	Line ID	λ μm	ν (1/cm)	Laser ID	Line ID	λ μm	ν (1/cm)
DF	P3(7)	3.8903	2570.496	CO	P4(8)	4.9185	2033.142
MISC		3.9000	2564.103	CO	P4(9)	4.9282	2029.127
DF	P1(14)	3.9107	2557.087	CO	P4(10)	4.9381	2025.079
DF	P2(11)	3.9155	2553.953	CO	P4(11)	4.9481	2020.997
DF	P3(8)	3.9272	2546.343	CO	P5(7)	4.9724	2011.091
DF	P4(5)	3.9487	2532.479	CO	P5(8)	4.9822	2007.145
DF	P2(12)	3.9565	2527.486	CO	P5(9)	4.9921	2003.165
DF	P3(9)	3.9654	2521.813	CO	P5(10)	5.0021	1999.152
DF	P4(6)	3.9843	2509.851	CO	P5(11)	5.0123	1995.105
DF	P2(13)	3.9995	2500.313	CO	P5(12)	5.0225	1991.025
DF	P3(10)	4.0054	2496.629	CO	P5(13)	5.0329	1986.911
DF	P4(7)	4.0212	2486.820	CO	P5(14)	5.0435	1982.765
DF	P2(14)	4.0435	2473.105	CO	P6(8)	5.0474	1981.219
DF	P3(11)	4.0464	2471.333	CO	P5(15)	5.0541	1978.585
DF	P4(8)	4.0597	2463.236	CO	P6(9)	5.0575	1977.274
MISC		4.0700	2457.002	CO	P6(10)	5.0677	1973.296
DF	P3(12)	4.0895	2445.287	CO	P6(11)	5.0780	1969.284
DF	P4(9)	4.0996	2439.262	CO	P6(12)	5.0885	1965.234
DF	P3(13)	4.1337	2419.140	MISC		5.4000	1851.852
DF	P2(16)	4.1369	2417.269	MISC		9.2800	1077.586
DF	P3(14)	4.1798	2392.459	MISC		9.5500	1047.120
DF	P2(17)	4.1862	2388.802	MISC		10.2500	975.610
MISC		4.2300	2364.066	MISC		10.4000	961.538
MISC		4.4000	2272.727	CO2	P(20)	10.5910	944.198
MISC		4.9000	2040.816	MISC		11.0000	909.091
CO	P4(7)	4.9089	2037.123				

1.4.2 Model Atmospheres

LZTRAN allows users to input their own atmosphere or select one of six model atmospheres to establish vertical pressure, temperature, and partial pressure of water vapor profiles. Table 1.2 lists the six models in LZTRAN:

Table 1.2: Models in LZTRAN

Index Identifier	Model Atmosphere	Effective Scale Height (m)
1	TROPICAL	8410.12
2	MIDATITUDE SUMMER	8284.91
3	SUBARCTIC SUMMER	8009.15
4	MIDLATITUDE WINTER	7689.13
5	SUBARCTIC WINTER	7407.93
6	US STANDARD (1962)	7955.95

These are the same atmospheres used in the AFGL codes atmospheric transmittance and radiance (LOWTRN) [Kneizys and et al, 1983] and LASER[McClatchey and D'Agati, 1978], although the LZTRAN module considers the atmospheres only between sea level and 5 km.

1.4.3 Pressure

Pressure is calculated by assuming hydrostatic equilibrium and an effective scale height determined for each atmosphere from the following expression:

$$H_{\text{eff}}(\text{model}) = \ln \frac{P(\text{sea level})}{P(5000\text{m})} \Delta h \quad (1.6)$$

where

$\Delta = 5000$ m

$P()$ = total pressure at sea level and 5 km for this model

The advantage of using an effective scale height is that the pressure can be calculated for any altitude without interpolation. The module computes pressures by using the hydrostatic equilibrium equation:

$$P_2 = P_1 \exp[(ALT(1) - ALT(2))/H_{\text{eff}}] \quad (1.7)$$

where

P_1 = total pressure at altitude 1 [$ALT(1)$]

P_2 = total pressure at altitude 2 [$ALT(2)$]

Reference P_1 and $ALT(1)$ values are supplied by the user.

Table 1.3 displays the vertical pressure structure for the six atmospheric models included in LZTRAN.

1.4.4 Temperature

Table 1.4 gives the model atmosphere temperatures included in the LZTRAN module. Temperatures needed for altitudes falling between those given in the table are linearly interpolated. Figure 1.1 is a plot of these

model temperatures versus altitude. If users wish to use a particular model but find that the temperature data they have for a given altitude does not equal the model temperature, they may still use the model lapse rate. LZTRAN will calculate a zero point shift by using the lapse rate of the selected model to match the user input temperature at the given altitude, and the model vertical temperature profile will be shifted by that constant. For example, assume the user desires the US Standard Atmosphere temperature profile, but requires a temperature of 290.09 K at 1 km instead of a temperature of 281.6 K established by the model. LZTRAN will add 8.4 K to every point on the profile, thereby shifting the US Standard Atmosphere temperature profile 8.4 K higher. If the temperature profiles provided by LZTRAN prove inappropriate, users may elect to input their own vertical temperature profile (see chapter 2).

Table 1.3: Model Atmosphere Vertical Pressure Structure for LZTRAN (in millibars)

Alt (km)	Tropical	Midlat Summer	Midlat Winter	Subarctic Summer	Subarctic Winter	US Standard
0	1.013E+03	1.013E+03	1.018E+03	1.010E+03	1.013E+03	1.013E+03
1	9.040E+02	9.020E+02	8.973E+02	8.960E+02	8.878E+02	8.986E+02
2	8.040E+02	8.020E+02	7.897E+02	7.929E+02	7.775E+02	7.950E+02
3	7.150E+02	7.100E+02	6.938E+02	7.000E+02	6.798E+02	7.012E+02
4	6.330E+02	6.280E+02	6.081E+02	6.160E+02	5.932E+02	6.166E+02
5	5.590E+02	5.540E+02	5.313E+02	5.410E+02	5.158E+02	5.405E+02

Table 1.4: Model Atmosphere Temperature Structure for LZTRAN (in degrees Kelvin)

Alt (km)	Tropical	Midlat Summer	Midlat Winter	Subarctic Summer	Subarctic Winter	US Standard
0	300.0	294.0	272.2	287.0	257.1	288.1
1	294.0	290.0	268.7	282.0	259.1	281.6
2	288.0	285.0	265.2	276.0	255.9	275.1
3	284.0	279.0	261.7	271.0	252.7	268.7
4	277.0	273.0	255.7	266.0	247.7	262.2
5	270.0	267.0	249.7	260.0	240.9	255.7

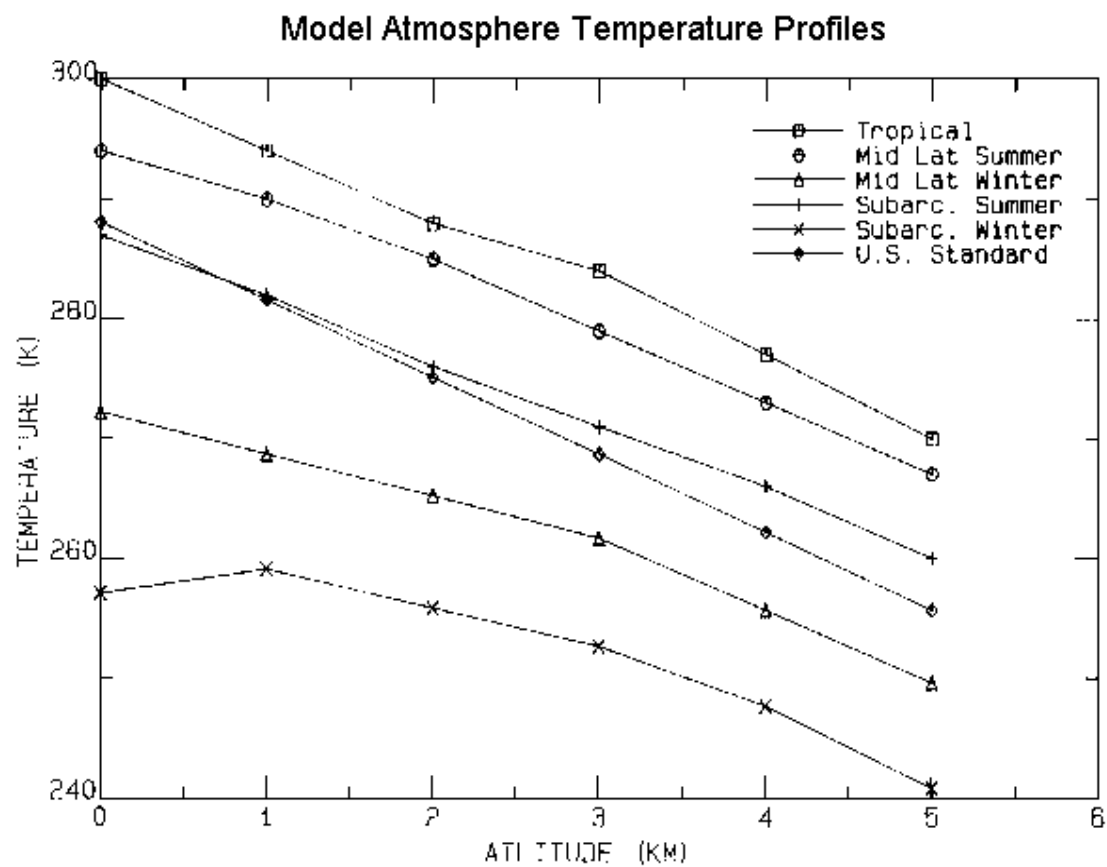


Figure 1.1: Vertical temperature profiles for the six model atmospheres offered by LZTRAN.

1.4.5 Partial Pressure of Water Vapor

As with temperature, values of water vapor pressure for altitudes occurring between those listed in table 1.5 are linearly interpolated. However, users must accept the water vapor pressure profiles of the models exactly, or input their own profile (that is, no offset profile is calculated).

The LZTRAN module will not allow values of water vapor above saturation. If such a situation occurs, the model will issue a warning and reset the water vapor pressure to saturation value. Saturation is checked by using the algorithm given by Pruppocher and Klett[Pruppocher and Klett, 1978]:

$$e(\text{sat}) = \alpha_0 + t(\alpha_1 + t(\alpha_2 + (\alpha_3 + \alpha_4 + t(\alpha_5 + \alpha_6 t)))) \quad (1.8)$$

where

$e(\text{sat})$ = saturation water vapor partial pressure (millibars)

t = ambient air temperature (degrees Celsius)

$\alpha_0 - \alpha_6$ = coefficients found in the LZTRAN data statement **WSAT**

Table 1.5: Model Atmosphere Partial Pressure of Water Vapor Structure for LZTRAN

Alt (km)	Tropical	Midlat Summer	Midlat Winter	Subarctic Summer	Subarctic Winter	US Standard
0	1.9E+01	1.4E+01	3.5E+00	9.1E+00	1.2E+00	5.9E+00
1	1.3E+01	9.3E+00	2.5E+00	6.0E+00	1.2E+00	4.2E+00
2	9.3E+00	5.9E+00	1.8E+00	4.2E+00	9.4E-01	2.9E+00
3	4.7E+00	3.3E+00	1.2E+00	2.7E+00	6.8E-01	1.8E+00
4	2.2E+00	1.9E+00	6.6E-01	1.7E+00	4.1E-01	1.1E+00
5	1.5E+00	1.0E+00	3.8E-01	1.0E+00	2.0E-01	6.4E-10

Figure 1.2 displays the six model atmosphere water vapor pressure structures. This figure can help users with sparse vertical structure data to construct their own input water vapor structure.

1.5 Continuum Absorption (H₂O and N₂)

The polynomial coefficients used for calculating the molecular absorption coefficients in LZTRAN do not include the continuum contribution of water vapor (3.33 μm to 4.2 μm and 8 μm to 12 μm) or nitrogen (3.65 μm to 4.8 μm). Continuum absorptions for these molecules are computed in the LZTRAN subroutine **LZCONT**. This approach allows users to substitute their own continuum algorithms in LZTRAN by modifying **LZCONT**. Alternatively, since LZTRAN yields both the absorption coefficients with and without the continuum contributions, the user may choose to manually add a desired continuum value to the molecular absorption coefficient after the LZTRAN calculations.

The following is a brief summary of the H₂O and N₂ continuum algorithms currently found in LZTRAN, following the expressions given in LOWTRN5. More complete descriptions and references are found in the LOWTRN and LASER documentations.

1.5.1 Water Vapor Continuum

Since no completely satisfactory theoretical description of the water vapor continuum currently exists, empirical expressions based on experimental measurements are necessarily used to account for the continuum

attenuation. Such measurements and the results, due to the work of Roberts et al,[Roberts *et al.*, 1976] Burch,[Burch, 1970] and Burch et al,[Burch *et al.*, 1971] are thus used in LZTRAN. The continuum absorption coefficients computed from the following expression:

$$k_\nu = C_s(\nu, 296)W_i(z) \quad (1.9)$$

where

$C_s(\nu, 296)$ = self-broadening coefficient for H₂O
 W_i = (see equations 1.11 and 1.12)
 i = 1 is for 8 μ m to 12 μ m
 i = 2 is for 3.3 μ m to 4.2 μ m

The 8 μ m to 12 μ m Continuum: In this region,

$$C_s(\nu, 296) = 4.18 + 5578 \exp(-7.87 \times 10^{-3}\nu) \quad (1.10)$$

and

$$W_1(z) = w(z) \left\{ P_{\text{H}_2\text{O}} \exp \left[6.08 \left(\frac{296}{T} - 1 \right) \right] + 0.002(P_{\text{T}} - P_{\text{H}_2\text{O}}) \right\} \quad (1.11)$$

where

z = altitude
 ν = wavenumber (cm⁻¹)
 $w(z)$ = g cm⁻²/km of H₂O in path at temperature T (degrees kelvin)
 $P_{\text{H}_2\text{O}}$ = partial pressure of H₂O
 P_{T} = ambient (total) pressure

The value 0.002 is the ratio of the foreign (nitrogen) broadening coefficient to the self-broadening coefficient, C_N/C_S . The ratio is assumed temperature independent, although the measured ratio is for 296 K.

The 3.3 μ m to 4.8 μ m Continuum: The self-broadening absorption coefficients in this region are calculated from the values given in table 1.6. Fourth-order polynomials have been fit to the values in table 1.6 in the regions 2350 to 2650 cm⁻¹. The polynomial determined values also appear in the table. The second term in equation 1.9 for this region is

$$W_2(z) = w(z) \left[P_{\text{H}_2\text{O}} + 0.12(P_{\text{T}} - P_{\text{H}_2\text{O}}) \right] \exp \left[6.08 \left(\frac{296}{T} - 1 \right) \right] \quad (1.12)$$

where the symbols are the same as above. The coefficient 0.12 is the nitrogen broadening value determined by Burch et al[Burch *et al.*, 1971] at a temperature of 428 K.

1.5.2 Nitrogen Continuum

Figure 1.3 displays the absorption coefficients $C_N(\nu)$ for the nitrogen continuum. The figure, generated from the data table in LZCONT, is from the work of Reddy and Cho[Reddy and Cho, 1965] and Shapiro and Gush.[Shapiro and Gush, 1966] The absorption coefficient for the N₂ continuum is computed in LZCONT by:

$$k(\nu, T, P) = C_N(\nu)[P_{\text{T}}(z)/1013]^2[296/T(z)] \times 0.781 \quad (1.13)$$

where

$P(z)$ = ambient pressure (millibars) at altitude Z
 $T(z)$ = ambient temperature (degrees kelvin) at altitude Z
0.781= the assumed fractional concentration of molecular nitrogen in the atmospheric region of interest.

1.6 Caveats

The LZTRAN calculations are considered valid only between sea level and 5 km (total pressures between 1013 and 500 millibar). The ozone number density has been held constant throughout the atmosphere considered. Therefore, the user should be cautious when working in spectral regions where ozone is a significant contributor to the extinction.

The output of LZTRAN is based on the plane-parallel atmosphere and no corrections for refraction or curvatures have been made. Because of the upper altitude limit of the module, the plane-parallel approximations breaks down only for extremely long paths obtained at large zenith angles.

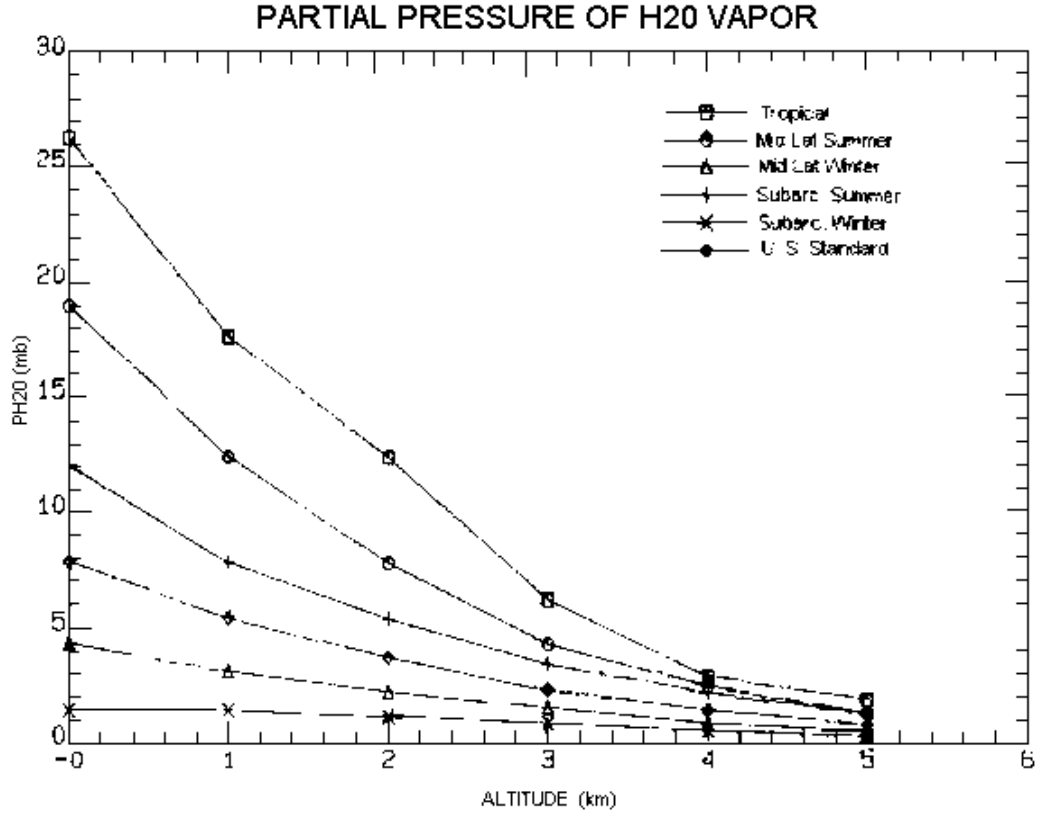


Figure 1.2: Vertical partial pressure of water vapor profiles for the six model atmospheres offered by LZTRAN.

Table 1.6: Self-Broadening Absorption Coefficients for Water Vapor Continuum ($3.3\mu\text{m}$ to $4.2\mu\text{m}$)

Wavenumber (cm^{-1})	CS(v, 296) ($\text{cm}^2/\text{g-atm}$)	CS(v, 296) (POLY FIT)
2350	0.230	0.230
2400	0.187	0.186
2450	0.147	0.148
2500	0.117	0.117
2550	0.097	0.096
2600	0.087	0.088
2650	0.100	0.100
2700	0.120	0.119
2750	0.147	0.147
2800	0.174	0.173
2850	0.200	0.202
2900	0.240	0.238
2950	0.280	0.281
3000	0.330	0.330

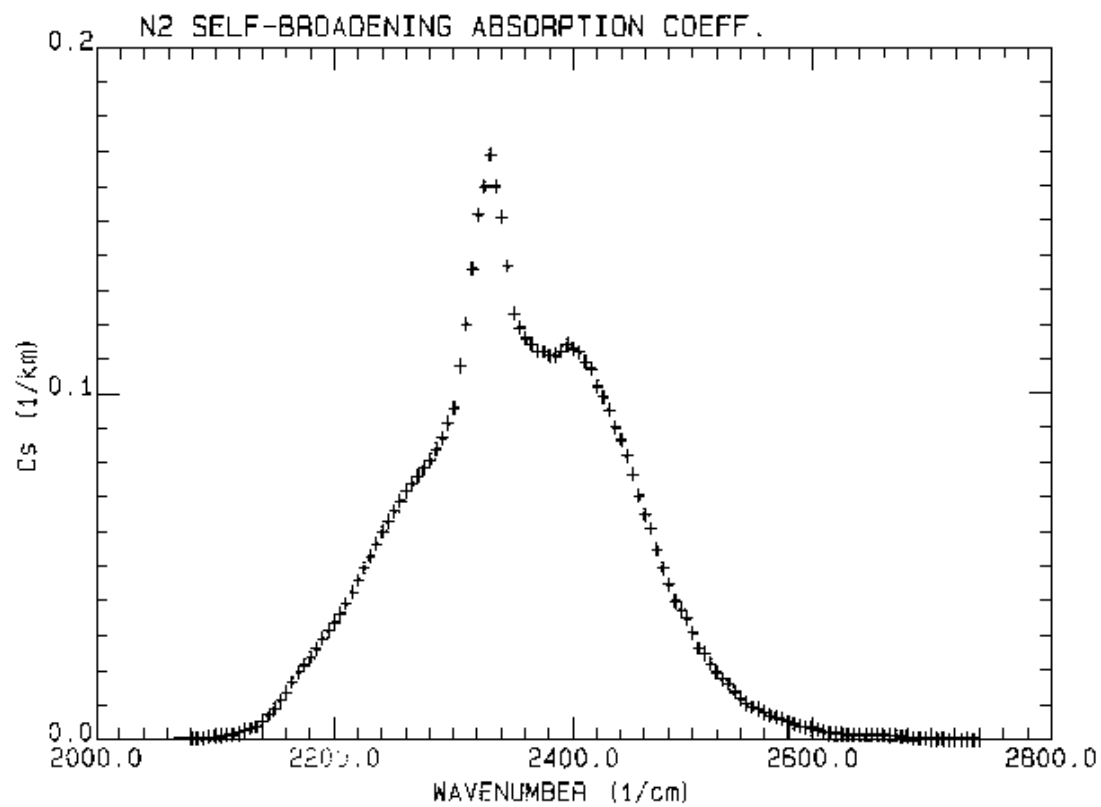


Figure 1.3: The N₂ self-broadening absorption coefficients by LZTRAN for computing the N₂ continuum absorption in the 4 μ m region.

Chapter 2

USER'S GUIDE

2.1 Introduction

The LZTRAN module calculates molecular absorption coefficients (kilometers^{-1}) for specific laser frequencies of DF, CO, CO₂, GA:AS, Kr⁺ and Alexandrite lasers. A selected number of additional wavelengths may also be addressed (table 1). The transmission, as a function of pressure, temperature, and partial pressure of water vapor, is calculated for horizontal or slant path lines of sight (LOS). Calculations of LZTRAN are valid for $1013 > P > 500$ millibar, $260 > T > 320$ K and $0 > P_w > 75$ millibar. (The range in the partial pressure of water vapor is subject to saturation limits.)

2.2 Input

The input for LZTRAN is card order independent and is read with a common format (A4, 6X, 7E10.4). Seven types of data cards can be read in the LZTRAN module, but they are not all necessarily required for a given run. The various input cards and their input formats are outline below.

If the **WAVE** card is not present, then the passed wavelength from Electro-Optical Systems Atmospheric Effects Library (EOSAEL)Executive Routine (EOEXEC) or you program will be used. If the **WAVE** card is present, it will override any value of wavelength passed from another program (i.e. EOEXEC).

The target and designator coordinates can be passed from EOEXEC or you program via the **GO**, **TARG** and **GEO**, **DESG** input cards. The coordinates entered in kilometers, are converted to meters in LZTRAN using the variables **PTM(1--3)** as the target location and **PTM(4--6)** as the laser designator location. If the (**GEO**, **TARG**) and (**GEO**, **DESG**) cards are not read into EOEXEC, then the **TARG** and **DESG** cards must be read into LZTRAN **PTM** variables.

2.2.1 WAVE Card

Used to specify the laser line if you wish to run multiple cycles in LZTRAN for different wavelengths. This card can be used in lieu of returning to the EOEXEC or your program.

Table 2.1: The **WAVE** Card.

1	2	3	4	5	6	7	8
1234567890123456789012345678901234567890123456789012345678901234567890							
WAVE	WAVEL						
NAME	UNITS	Description					
WAVEL	μm	Laser line wavelength.					

2.2.2 ATMO Card

Used to input atmospheric parameters. This card required for every cycle.

Table 2.2: The **ATMO** Card.

1	2	3	4	5	6	7	8
1234567890123456789012345678901234567890123456789012345678901234567890							
ATMO	PRES	TMP	PHGHT	MSCL	SCLHT	ZDEL	
NAME	UNITS	Description					
PRES	millibars	Total atmospheric pressure (including water vapor) at designated reference altitude (PHGHT).					
TMP	degrees C	Temperature at reference altitude (PHGHT).					
PHGHT	km	Reference altitude. Usually that of the laser position (designator) but may be any height the user selects. Equal to or greater than ALT(1) .					
MSCL		Model atmosphere ID number (see table 1.2) used in selecting a mean scale height of the desired model atmosphere. If MSCL = 0.0, then the US Standard Atmosphere Scale height is used. If MSCL > 6.0, then SCLHT					
		should be entered by the user.					
SCLHT	km	Mean scale height for user entered atmosphere. An entry of 0.0 with MSCL > 6.0 will default the US Standard Atmosphere value of 7.955 km (mean scale height for the atmosphere from 0 to 5 km).					
ZDEL	km	Initial layer thickness in teh atmosphere for which pressure, temperature, and water vapor pressure are considered constant. A value larger than 500 m will be reset to 500 m. Default is 500 m.					

2.2.3 TEMP Card

Used for designating vertical temperature profile. This card is required for every cycle.

Table 2.3: The **TEMP** Card.

1	2	3	4	5	6	7	8
1234567890123456789012345678901234567890123456789012345678901234567890							
TEMP	MTMP	TMP(1)	TMP(2)	TMP(3)	TMP(4)	TMP(5)	TMP(6)
NAME	UNITS	Description					
MTMP		Model ID number for vertical temperature structure. If MTMP > 6, then water vapor pressures must follow.					
TMP(1-6)	degrees C	Vertical temperature profile. (See ALTL for corresponding altitudes)					

2.2.4 PH20 Card

Used for designating the water vapor pressure vertical profile. This card is required for every cycle.

Table 2.4: The **PH20** Card.

1	2	3	4	5	6	7	8
1234567890123456789012345678901234567890123456789012345678901234567890							
PH20	MWPR	WP(1)	WP(2)	WP(3)	WP(4)	WP(5)	WP(6)
NAME	UNITS	Description					
MWPR		Model ID number for vertical water vapor pressure structures. This card is required for every cycle.					
WP(1-6)	millibar	Water vapor pressure profile. (See ALTL for corresponding altitudes.)					

2.2.5 ALTL Card

Used to assign the altitude for temperature and water vapor pressure structures. This card is required for every cycle.

Table 2.5: The **ALTL** Card.

1	2	3	4	5	6	7	8
1234567890123456789012345678901234567890123456789012345678901234567890							
ALTL	MALT	ALT(1)	ALT(2)	ALT(3)	ALT(4)	ALT(5)	ALT(6)
NAME	UNITS	Description					
MALT		If MALT \leq 6, then the TMP and WP values are assumed to be for altitudes of 0, 1, 2, 3, 4, and 5 km above sea level, that is, no altitude information need follow. If MALT > 6, then altitudes (km above sea level) must follow.					

2.2.6 TARG Card

Used to enter target position (X,Y,Z). Overrides coordinates passed from EOEXEC or your program.

Table 2.6: The **TARG** Card.

1	2	3	4	5	6	7	8
1234567890123456789012345678901234567890123456789012345678901234567890							
TARG	PTM(1)	PTM(2)	PTM(3)				
NAME	UNITS	Description					
PTM(1-3)	km	Coordinates of target X=1, Y=2, Z=3. Used to enter laser position.					

2.2.7 DESG Card

Used to enter laser position (X,Y,Z).

Table 2.7: The **DESG** Card.

1	2	3	4	5	6	7	8
1234567890123456789012345678901234567890123456789012345678901234567890							
DESG	PTM(4)	PTM(5)	PTM(6)				
NAME	UNITS	Description					
PTM(4-6)	km	Coordinates of laser, X=4, Y=5, Z=6.					

2.2.8 GO Card

Signifies to begin execution and more data are expected (multiple internal cycles).

Table 2.8: The **GO** Card.

1	2	3	4	5	6	7	8
1234567890123456789012345678901234567890123456789012345678901234567890							
GO							
NAME	UNITS	Description					
GO		End of read sentinel.					

2.2.9 DONE Card

Signifies to begin execution and more data are expected (multiple internal cycles).

Table 2.9: The **DONE** Card.

1	2	3	4	5	6	7	8
1234567890123456789012345678901234567890123456789012345678901234567890							
DONE							
NAME	UNITS	Description					
DONE		End of execution sentinel.					

2.3 Subroutines

The LZTRAN92 module is comprised of four subroutines: **LZTRAN**, **LZIDNM**, **COEFF**, and **LZCONT**.

2.3.1 LZTRAN

LZTRAN is the main subroutine of the module, primarily providing bookkeeping services and linking LZTRAN92 to EOEXEC or some external program. This subroutine reads input data cards, establishes the model atmosphere, determines how the atmosphere is to be segmented, calculates the total absorption coefficient and transmission over the LOS, and writes the output. Error checks on input are made and warnings issued if the input errors are not considered fatal. For example, a warning is issued if the partial pressure of water vapor is above the saturation. **LZTRAN** resets the water vapor pressure equal to the saturation value and the calculations continue. An example of a fatal error is a request for wavelength greater than $11.0\mu\text{m}$ or less than $0.64\mu\text{m}$. In this case, a message is issued and the program is returned to EOEXEC or the your program.

2.3.2 LZIDNM

LZIDNM converts the wavelength (micrometers) to an integer laser identification number (LID) used by **LZTRAN**. This subroutine searches for a wavelength match in the **AWAVEL** array. If an exact match is not found, the nearest tabulated wavelength to the input wavelength is used and a warning message is printed.

2.3.3 COEFF

The subroutine **COEFF** is a data storage routine that holds all of the polynomial coefficients used for calculating the molecular absorption coefficients. The coefficients are stored in "DATA" statements that correspond to the coefficients used in equation 1.2. The LID, determined in **LZIDNM**, is used to locate the coefficients for the requested laser wavelength. It is important to note that the coefficient locations are equal to the respective LID numbers (that is, the locations of the laser names and wavelengths in the **NAME** and **AWAVEL** arrays contained in **LZIDNM**). With the LID from **LZIDNM**, the subroutine **COEFF** locates the proper coefficients and passes them to **LZTRAN**. If core storage is a problem for the user, this subroutine can be removed and the data treated as an input file. The specifics of this procedure will depend upon the user's system and requirements. Some modification of **LZTRAN** will be required if this approach becomes necessary.

2.3.4 LZCONT

The **LZCONT** subroutine constitutes a major change in the LZTRAN module. Previous LZTRAN modules have had continuum contributions of H_2O and N_2 implicitly included in the polynomial coefficients used for calculating the atmospheric absorption coefficients. This forced the user to accept the continuum algorithms used in generating these coefficients. The approach taken for LZTRAN92 has been to omit the continuum contributions from the molecular absorption coefficients. The continuum absorption coefficient is calculated in **LZCONT** and added to the molecular absorption in **LZTRAN**. Details of the algorithms used in LZTRAN92 are found in section 1.5. **LZCONT** determines continuum absorption coefficients for each atmospheric layer along the LOS and returns these coefficients for each atmospheric layer along the LOS and returns these coefficients to **LZTRAN**. The self-broadening coefficient of H_2O in the $3.5\mu\text{m}$ to $4.2\mu\text{m}$ region is calculated by one of three fourth-order polynomials (dependent upon wavelength) that have been least squares fit to the data found in table 1.6. The self-broadening coefficients of H_2O in the $8\mu\text{m}$ to $12\mu\text{m}$ region are calculated by using equations 1.9, 1.10, 1.11; the N_2 self-broadening coefficients are determined by linear interpolation of the data table CSNZ found in LZCONT (figure 1.3). This subroutine is easily modified to accept a user-preferred algorithm for one or more of these continuum regions.

2.4 Examples of Use

The following examples are offered to illustrate the use of LZTRAN and to display the input and output of the module. These examples present only two of the many optional scenarios the LZTRAN package allows.

2.4.1 Example 1

In this first example, the transmittance of the DF P3(14) line at $4.1798\mu\text{m}$ is calculated for three different atmospheric conditions. The atmospheric conditions include the US Standard Atmosphere, the Tropical Model Atmosphere, and the Tropical Model with a user-specified partial pressure of water vapor vertical profile.

In this example, the requested laser line is entered in EOEXEC or your program by using the WAVL card. The (GEO, TARG) and (GEO, DESG) are not used to enter the laser and target positions, although these cards could be used. The second EOEXEC card is LZTRAN which calls the LZTRAN module. Once LZTRAN, the TARG and DESG cards are used to specify the target and laser coordinates. Note that these coordinates are X, Y, Z values in kilometers. The F10.4 format allows 0.1 m resolution.

For any cycle, the ATMO, TEMP, PH2O, and ALTL cards are required but are order independent. The first cycle in the example is for the US Standard Atmosphere, the second cycle is for the Tropical Model Atmosphere, and the third cycle is for the Tropical Model with modifications to the partial pressure of water vapor vertical profile.

The ATMO card for cycle one specifies a reference pressure and temperature of 1013.25 millibar and 14.95°C (288.1 K), respectively, at an altitude of 0.0 km above sea level. By using tables 1.3 and 1.4, any set of values for pressure and temperature from the US Standard Atmosphere can be used as long as the third variable on the card specifies the proper altitude (see cycles two and three). The fourth variable on the ATMO card specifies the model atmosphere desired (table 1.2). This number is used in selecting the effective scale height needed to calculate the total pressure vertical profile. If this number is greater than 6.0, then the next variable, the effective scale height, must be entered by the user. Cycle one is completed by specifying 6.0 (US Standard Atmosphere, table 1.2) on the remaining cards. The GO card then starts the calculations and tells the module that more calculations for a different set of conditions will follow. The DONE card tells the module to return to EOEXEC or your program after completing the calculations. Cycle two is similar to cycle one except that the Tropical Model Atmosphere (identified by 1.0, table 1.2) is specified. Also note that the reference altitude (ATMO card) is now 1.0 km and that the appropriate pressure and temperature values for this altitude have been entered from tables 1.3 and 1.4.

Cycle three differs from cycle two only in that the partial pressure of water vapor vertical profile has been changed (that is, the model's vertical profile has been overridden). This change is accomplished through the PH2O card. The first variable on this card must be greater than 6.0 and followed by the desired partial pressures of water vapor. Since this example uses the Tropical Model Atmosphere temperatures profile as it is, the water vapor values must be for the same altitudes as the temperatures, that is, 0, 1, 2, 3, 4, and 5 km.

Also note that a new reference altitude has been used on cycle three, although the reference altitude, pressure, and temperature from cycle two would yield the same results.

Example 1 Input

WAVL	4.1798	0.0000	0.0000	0.0000	0.0000	0.0000	0.00
LZTRAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TARG	2.0000	0.0000	0.2000	0.0	0.0	0.0	0.0
DESG	0.0000	0.0000	4.6000	0.0	0.0	0.0	0.0
ATMO	1013.2500	14.95	0.0000	6.0000	0.0000	0.0000	0.0
TEMP	6.0	0.0	0.0	0.0	0.0	0.0	0.0
PH2O	6.0	0.0	0.0	0.0	0.0	0.0	0.0
ALTL	6.0	0.0	0.0	0.0	0.0	0.0	0.0
GO	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ATMO	904.0000	20.85	1.0000	1.0000	0.0000	0.0000	0.0

TEMP	1.0	0.0	0.0	0.0	0.0	0.0	0.0
PH2O	1.0	0.0	0.0	0.0	0.0	0.0	0.0
ALTL	1.0	0.0	0.0	0.0	0.0	0.0	0.0
GO	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ATMO	804.0000	14.85	2.0000	1.0000	0.0000	0.0000	0.0
TEMP	1.0	0.0	0.0	0.0	0.0	0.0	0.0
PH2O	7.0	45.00	25.00	12.00	6.00	3.0	1.0
ALTL	1.0	0.0	0.0	0.0	0.0	0.0	0.0
DONE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
END	0.0	0.0	0.0	0.0	0.0	0.0	0.0
STOP	0.0	0.0	0.0	0.0	0.0	0.0	0.0

THE FOLLOWING IS EOSAEL SOURCE CONTROL INFORMATION YOU CAN SAFELY REMOVE IT
SCCS @(#) LZTRAN01.DAT 1.1 03/10/93

Example 1 Output

```
*****
WARNING - THIS LIBRARY CONTAINS TECHNICAL DATA WHOSE EXPORT IS RESTRICTED
BY THE ARMS EXPORT CONTROL ACT (TITLE 22, U.S.C., SEC 2751 ET SEQ.) OR
EXECUTIVE ORDER 12470. VIOLATION OF THESE EXPORT LAWS ARE SUBJECT TO
SEVERE CRIMINAL PENALTIES.
*****
```

```
*****
*
*   ELECTRO-OPTICAL SYSTEMS   *
*
*   ATMOSPHERIC EFFECTS LIBRARY *
*
*   NOT FOR OPERATIONAL USE   *
*
* EOSAEL92 REV 1.1    03/10/93 *
*
*****
```

0

	BEGINNING	ENDING
WAVENUMBER (CM**-1)	2392.459	2392.459
WAVELENGTH (MICROMETERS)	4.180	4.180
FREQUENCY (GHZ)	71773.766	71773.766

**** EOSAEL WARNING ****
VISIBILITY AND EXTINCTION = 0.0, VISIBILITY CHANGED TO 10.0 KM

0

VISIBILITY
10.00 KM

```
*****
*
*           L Z T R A N           *
*
*   CALCULATE MOLECULAR          *
*   ABSORPTION COEFFICIENTS      *
*   AT SELECT LASER FREQUENCIES  *
*
*   EOSAEL92 REV 1.1   03/10/93  *
*
*****
```

1

```
*****
*
*   TRANSMITTANCE RESULTS        *
*
*****
```

WAVELENGTH (MICRONS)	LINE ID	PATHLENGTH (KM)	OPTICAL DEPTH	TRANSMISSION
-----	-----	-----	-----	-----
4.1798	DF P3(14)	4.833	5.3436	.0048

DESIGNATOR POSITION (X,Y,Z): .00 .00 4600.00 METERS

TARGET POSITION (X,Y,Z): 2000.00 .00 200.00 METERS

MODEL ATMOS: PRESSURE: U.S.STANDARD EFFECTIVE SCALE HT: 7955.9 METERS
 TEMPERATURE: U.S.STANDARD
 H2O VAPOR PRESS: U.S.STANDARD

REFERENCE ALTITUDE (METERS): .0
 REFERENCE PRESSURE (MB): 1013.3
 REFERENCE TEMPERATURE (KELVIN): 288.11

----- ATMOSPHERIC LAYERS -----

PATH THRU LAYER (KM)	MIDLAYER ALTITUDE (M)	PRESSURE (MB)	TEMP (K)	H2O VAPOR (MB)	OPTICAL MOLECULAR ABSORPTN	DEPTH CONTINUUM H2O / N2	EXTINCTN COEFF (1/KM)
-----	-----	-----	-----	-----	-----	-----	-----
.269	4477.8	577.1	259.10	1.056	.1735	.0094	.6811
.269	4233.3	595.2	260.69	1.197	.1833	.0100	.7199

.269	3988.9	613.7	262.28	1.341	.1934	.0106	.7596
.269	3744.4	632.9	263.87	1.561	.2037	.0113	.8007
.269	3500.0	652.6	265.46	1.782	.2145	.0120	.8433
.269	3255.6	673.0	267.05	2.002	.2256	.0127	.8876
.269	3011.1	694.0	268.64	2.222	.2373	.0135	.9340
.269	2766.7	715.6	270.20	2.570	.2495	.0144	.9829
.269	2522.2	738.0	271.77	2.924	.2624	.0153	1.0345
.269	2277.8	761.0	273.33	3.279	.2761	.0163	1.0890
.269	2033.3	784.7	274.90	3.633	.2906	.0173	1.1469
.269	1788.9	809.2	276.48	4.056	.3061	.0184	1.2085
.269	1544.4	834.5	278.07	4.490	.3226	.0196	1.2743
.269	1300.0	860.5	279.66	4.924	.3403	.0208	1.3447
.269	1055.6	887.4	281.25	5.358	.3593	.0221	1.4203
.269	811.1	915.0	282.84	5.908	.3797	.0235	1.5015
.269	566.7	943.6	284.43	6.491	.4016	.0250	1.5889
.269	322.2	973.0	286.02	7.074	.4254	.0266	1.6830

1
1

```

*****
*                                     *
*           TRANSMITTANCE RESULTS           *
*                                     *
*****

```

WAVELENGTH (MICRONS)	LINE ID	PATHLENGTH (KM)	OPTICAL DEPTH	TRANSMISSION
-----	-----	-----	-----	-----
4.1798	DF P3(14)	4.833	5.2581	.0052

DESIGNATOR POSITION (X,Y,Z): .00 .00 4600.00 METERS

TARGET POSITION (X,Y,Z): 2000.00 .00 200.00 METERS

MODEL ATMOS: PRESSURE: TROPICAL EFFECTIVE SCALE HT: 8410.1 METERS
 TEMPERATURE: TROPICAL
 H2O VAPOR PRESS: TROPICAL

REFERENCE ALTITUDE (METERS): 1000.0
 REFERENCE PRESSURE (MB): 904.0
 REFERENCE TEMPERATURE (KELVIN): 294.01

----- ATMOSPHERIC LAYERS -----

PATH THRU LAYER (KM)	MIDLAYER ALTITUDE (M)	PRESSURE (MB)	TEMP (K)	H2O VAPOR (MB)	OPTICAL MOLECULAR ABSORPTN	DEPTH CONTINUUM H2O / N2	EXTINCTN COEFF (1/KM)
-----	-----	-----	-----	-----	-----	-----	-----
.269	4477.8	597.8	273.67	2.361	.1747	.0099	.6875
.269	4233.3	615.5	275.38	2.592	.1836	.0105	.7229
.269	3988.9	633.6	277.09	2.849	.1928	.0111	.7594
.269	3744.4	652.3	278.80	3.667	.2021	.0120	.7972
.269	3500.0	671.5	280.51	4.485	.2117	.0129	.8363
.269	3255.6	691.3	282.22	5.304	.2217	.0138	.8771
.269	3011.1	711.7	283.93	6.122	.2321	.0148	.9197
.269	2766.7	732.7	284.94	7.605	.2435	.0162	.9671

.269	2522.2	754.3	285.92	9.121	.2555	.0177	1.0174
.269	2277.8	776.6	286.90	10.636	.2683	.0192	1.0709
.269	2033.3	799.5	287.88	12.151	.2820	.0208	1.1278
.269	1788.9	823.1	289.28	13.472	.2963	.0223	1.1866
.269	1544.4	847.3	290.74	14.762	.3116	.0239	1.2492
.269	1300.0	872.3	292.21	16.051	.3280	.0254	1.3163
.269	1055.6	898.0	293.68	17.341	.3457	.0271	1.3883
.269	811.1	924.5	295.14	19.271	.3646	.0291	1.4663
.269	566.7	951.8	296.61	21.389	.3850	.0314	1.5506
.269	322.2	979.9	298.08	23.507	.4071	.0337	1.6417

1

*** WARNING *** H2O VAPOR PRESSURE AT ALTITUDE 933.3 M IS GREATER THAN THE SATURATION PRESS. OF 25.24 MB.
 THE WATER VAPOR PRESS OF 26.33 MB IS RESET TO THE SATURATION VALUE.
 *** WARNING *** H2O VAPOR PRESSURE AT ALTITUDE 444.4 M IS GREATER THAN THE SATURATION PRESS. OF 30.16 MB.
 THE WATER VAPOR PRESS OF 36.11 MB IS RESET TO THE SATURATION VALUE.
 *** WARNING *** H2O VAPOR PRESSURE AT ALTITUDE 1055.6 M IS GREATER THAN THE SATURATION PRESS. OF 24.13 MB.
 THE WATER VAPOR PRESS OF 24.28 MB IS RESET TO THE SATURATION VALUE.
 *** WARNING *** H2O VAPOR PRESSURE AT ALTITUDE 811.1 M IS GREATER THAN THE SATURATION PRESS. OF 26.40 MB.
 THE WATER VAPOR PRESS OF 28.78 MB IS RESET TO THE SATURATION VALUE.
 *** WARNING *** H2O VAPOR PRESSURE AT ALTITUDE 566.7 M IS GREATER THAN THE SATURATION PRESS. OF 28.86 MB.
 THE WATER VAPOR PRESS OF 33.67 MB IS RESET TO THE SATURATION VALUE.
 *** WARNING *** H2O VAPOR PRESSURE AT ALTITUDE 322.2 M IS GREATER THAN THE SATURATION PRESS. OF 31.51 MB.
 THE WATER VAPOR PRESS OF 38.56 MB IS RESET TO THE SATURATION VALUE.

1

```

*****
*                                     *
*          TRANSMITTANCE RESULTS          *
*                                     *
*****

```

WAVELENGTH (MICRONS)	LINE ID	PATHLENGTH (KM)	OPTICAL DEPTH	TRANSMISSION
-----	-----	-----	-----	-----
4.1798	DF P3(14)	4.833	5.2885	.0050

DESIGNATOR POSITION (X,Y,Z): .00 .00 4600.00 METERS

TARGET POSITION (X,Y,Z): 2000.00 .00 200.00 METERS

MODEL ATMOS: PRESSURE: TROPICAL EFFECTIVE SCALE HT: 8410.1 METERS
 TEMPERATURE: TROPICAL
 H2O VAPOR PRESS: USER DEFINED

REFERENCE ALTITUDE (METERS): 2000.0
 REFERENCE PRESSURE (MB): 804.0
 REFERENCE TEMPERATURE (KELVIN): 288.01

----- ATMOSPHERIC LAYERS -----

PATH THRU LAYER (KM)	MIDLAYER ALTITUDE (M)	PRESSURE (MB)	TEMP (K)	H2O VAPOR (MB)	OPTICAL MOLECULAR ABSORPTN	DEPTH CONTINUUM H2O / N2	EXTINCTN COEFF (1/KM)
----	----	----	----	----	----	----	----
.269	4477.8	598.8	273.67	2.044	.1753	.0098	.6895
.269	4233.3	616.5	275.38	2.533	.1842	.0105	.7252
.269	3988.9	634.7	277.09	3.033	.1933	.0112	.7619
.269	3744.4	653.4	278.80	3.767	.2027	.0121	.7998
.269	3500.0	672.7	280.51	4.500	.2123	.0130	.8390
.269	3255.6	692.5	282.22	5.233	.2224	.0139	.8798
.269	3011.1	712.9	283.93	5.967	.2329	.0148	.9225
.269	2766.7	733.9	284.94	7.400	.2443	.0162	.9701
.269	2522.2	755.6	285.92	8.867	.2564	.0176	1.0206
.269	2277.8	777.9	286.90	10.333	.2693	.0191	1.0742
.269	2033.3	800.8	287.88	11.800	.2831	.0207	1.1314
.269	1788.9	824.4	289.28	14.744	.2967	.0231	1.1910
.269	1544.4	848.8	290.74	17.922	.3114	.0256	1.2552
.269	1300.0	873.8	292.21	21.100	.3274	.0283	1.3248
.269	1055.6	899.6	293.68	24.130	.3450	.0310	1.4001
.269	811.1	926.1	295.14	26.402	.3642	.0333	1.4805
.269	566.7	953.4	296.61	28.858	.3851	.0358	1.5676
.269	322.2	981.5	298.08	31.512	.4078	.0385	1.6622

1

TOTAL TRANMITANCE FOR ALL SOURCES IS: .5049E-02

END EOSAEL RUN

1

2.4.2 Example 2

Here the transmittance of the CO₂ P(20) line at 10.591 μ m is calculated for three different transmission paths in the same atmosphere, which is chosen to be the US Standard Atmosphere with a slightly modified vertical temperature profile.

Again, the laser line wavelength is entered on the **WAVL** card in **EOEXEC**. Note that it has been entered as 10.6 instead of 10.591. The **LZTRAN** module will select the nearest wavelength in the wavelength table, issue a warning, and proceed with the calculations. Thus, the P(20) line of CO₂ has been selected. Normally, the user should enter wavelengths in table 1.1 to insure that the laser line desired is actually selected by **LZTRAN**.

In this example, the zenith angle between the laser and target is set at 0° (overhead), 45°, and 30°, respectively, with the laser at sea level and the target at 5.0 km above sea level.

The vertical pressure profile is that of the US Standard Atmosphere, but the vertical temperature profile is 4°C higher than the model's profile. The new temperature profile is established by setting the reference pressure and temperature on the **ATMO** card and 6.0 on the **TEMP** card. If the user wishes to enter a temperature profile with a different lapse rate than the US Standard Atmosphere Model, then a number greater than 6.0 must be entered on the **TEMP** card, followed by the values of temperature for the appropriate altitudes. This procedure has been illustrated in Example 1 for modifying the partial pressure of water vapor vertical profile.

In this example, the **TARG** and **DESG** cards must be entered in every cycle to change the laser-target coordinates (that is, path length of transmission).

Example 2 Input

WAVL	10.6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0
LZTRAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TARG	0.0000	0.0000	5.0000	0.0	0.0	0.0	0.0
DESG	0.0000	0.0000	0.0000	0.0	0.0	0.0	0.0
ATMO	1013.2500	18.95	0.0000	6.0000	0.0000	0.0000	0.0
TEMP	6.0	0.0	0.0	0.0	0.0	0.0	0.0
PH2O	6.0	0.0	0.0	0.0	0.0	0.0	0.0
ALTL	6.0	0.0	0.0	0.0	0.0	0.0	0.0
GO	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TARG	5.0000	0.0000	5.0000	0.0	0.0	0.0	0.0
DESG	0.0000	0.0000	0.0000	0.0	0.0	0.0	0.0
ATMO	1013.2500	18.95	0.0000	6.0000	0.0000	0.0000	0.0
TEMP	6.0	0.0	0.0	0.0	0.0	0.0	0.0
PH2O	6.0	0.0	0.0	0.0	0.0	0.0	0.0
ALTL	6.0	0.0	0.0	0.0	0.0	0.0	0.0
GO	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TARG	8.6600	0.0000	5.0000	0.0	0.0	0.0	0.0
DESG	0.0000	0.0000	0.0000	0.0	0.0	0.0	0.0
ATMO	1013.2500	18.95	0.0000	6.0000	0.0000	0.0000	0.0
TEMP	6.0	0.0	0.0	0.0	0.0	0.0	0.0
PH2O	6.0	0.0	0.0	0.0	0.0	0.0	0.0
ALTL	6.0	0.0	0.0	0.0	0.0	0.0	0.0
DONE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
END	0.0	0.0	0.0	0.0	0.0	0.0	0.0
STOP	0.0	0.0	0.0	0.0	0.0	0.0	0.0

THE FOLLOWING IS EOSAEL SOURCE CONTROL INFORMATION YOU CAN SAFELY REMOVE IT
 # SCCS @(#) LZTRAN02.DAT 1.1 03/10/93

Example 2 Output

 WARNING - THIS LIBRARY CONTAINS TECHNICAL DATA WHOSE EXPORT IS RESTRICTED
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 *
 * ELECTRO-OPTICAL SYSTEMS *
 *
 * ATMOSPHERIC EFFECTS LIBRARY *
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 * NOT FOR OPERATIONAL USE *
 *
 * EOSAEL92 REV 1.1 03/10/93 *
 *

0

BEGINNING

ENDING

WAVENUMBER (CM**-1)	943.396	943.396
WAVELENGTH (MICROMETERS)	10.600	10.600
FREQUENCY (GHZ)	28301.885	28301.885

**** EOSAEL WARNING ****
 VISIBILITY AND EXTINCTION = 0.0, VISIBILITY CHANGED TO 10.0 KM

0

VISIBILITY
 10.00 KM

```

*****
*                                     *
*           L Z T R A N             *
*                                     *
*   CALCULATE MOLECULAR             *
*   ABSORPTION COEFFICIENTS         *
*   AT SELECT LASER FREQUENCIES     *
*                                     *
*   EOSAEL92 REV 1.1   03/10/93    *
*                                     *
*****

```

***** WARNING *****
 *** INPUT WAVELENGTH 10.600 CHANGED TO 10.591 NEAREST STANDARD WAVELENGTH ***

1

```

*****
*                                     *
*   TRANSMITTANCE RESULTS           *
*                                     *
*****

```

WAVELENGTH (MICRONS)	LINE ID	PATHLENGTH (KM)	OPTICAL DEPTH	TRANSMISSION
-----	-----	-----	-----	-----
10.5910	CO2 P(20)	5.000	.3308	.7184
DESIGNATOR POSITION (X,Y,Z): .00 .00 .00 METERS				
TARGET POSITION (X,Y,Z): .00 .00 5000.00 METERS				
MODEL ATMOS: PRESSURE: U.S.STANDARD EFFECTIVE SCALE HT: 7955.9 METERS				
TEMPERATURE: U.S.STANDARD				
H2O VAPOR PRESS: U.S.STANDARD				

REFERENCE ALTITUDE (METERS): .0
REFERENCE PRESSURE (MB): 1013.3
REFERENCE TEMPERATURE (KELVIN): 292.11

----- ATMOSPHERIC LAYERS -----

PATH THRU LAYER (KM)	MIDLAYER ALTITUDE (M)	PRESSURE (MB)	TEMP (K)	H2O VAPOR (MB)	OPTICAL MOLECULAR ABSORPTN	DEPTH CONTINUUM H2O / N2	EXTINCTN COEFF (1/KM)
.227	113.6	998.9	291.37	7.572	.0186	.0098	.1245
.227	340.9	970.7	289.89	7.030	.0184	.0087	.1196
.227	568.2	943.4	288.42	6.487	.0181	.0078	.1138
.227	795.5	916.8	286.94	5.945	.0176	.0068	.1075
.227	1022.7	891.0	285.46	5.417	.0170	.0059	.1008
.227	1250.0	865.9	283.99	5.013	.0163	.0053	.0948
.227	1477.3	841.5	282.51	4.609	.0155	.0046	.0885
.227	1704.5	817.8	281.03	4.206	.0146	.0040	.0819
.227	1931.8	794.8	279.55	3.802	.0136	.0035	.0753
.227	2159.1	772.4	278.09	3.450	.0127	.0030	.0691
.227	2386.4	750.7	276.64	3.121	.0118	.0026	.0631
.227	2613.6	729.5	275.18	2.792	.0108	.0022	.0572
.227	2840.9	709.0	273.73	2.463	.0099	.0018	.0516
.227	3068.2	689.0	272.27	2.171	.0091	.0015	.0465
.227	3295.5	669.6	270.79	1.966	.0083	.0013	.0422
.227	3522.7	650.8	269.31	1.761	.0076	.0011	.0383
.227	3750.0	632.4	267.84	1.556	.0070	.0009	.0349
.227	3977.3	614.6	266.36	1.351	.0065	.0007	.0320
.227	4204.5	597.3	264.88	1.213	.0062	.0006	.0299
.227	4431.8	580.5	263.40	1.082	.0059	.0005	.0285
.227	4659.1	564.1	261.93	.951	.0059	.0004	.0277
.227	4886.4	548.3	260.45	.820	.0059	.0003	.0276

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1

*
* TRANSMITTANCE RESULTS *
*

WAVELENGTH (MICRONS)	LINE ID	PATHLENGTH (KM)	OPTICAL DEPTH	TRANSMISSION
10.5910	CO2 P(20)	7.071	.4678	.6264

DESIGNATOR POSITION (X,Y,Z): .00 .00 .00 METERS

TARGET POSITION (X,Y,Z): 5000.00 .00 5000.00 METERS

MODEL ATMOS: PRESSURE: U.S.STANDARD EFFECTIVE SCALE HT: 7955.9 METERS
TEMPERATURE: U.S.STANDARD
H2O VAPOR PRESS: U.S.STANDARD

REFERENCE ALTITUDE (METERS): .0
REFERENCE PRESSURE (MB): 1013.3

REFERENCE TEMPERATURE (KELVIN): 292.11

----- ATMOSPHERIC LAYERS -----

PATH THRU LAYER (KM)	MIDLAYER ALTITUDE (M)	PRESSURE (MB)	TEMP (K)	H2O VAPOR (MB)	OPTICAL MOLECULAR ABSORPTN	DEPTH CONTINUUM H2O / N2	EXTINCTN COEFF (1/KM)
.321	113.6	998.9	291.37	7.572	.0262	.0138	.1245
.321	340.9	970.7	289.89	7.030	.0261	.0124	.1196
.321	568.2	943.4	288.42	6.487	.0256	.0110	.1138
.321	795.5	916.8	286.94	5.945	.0249	.0096	.1075
.321	1022.7	891.0	285.46	5.417	.0241	.0083	.1008
.321	1250.0	865.9	283.99	5.013	.0230	.0074	.0948
.321	1477.3	841.5	282.51	4.609	.0219	.0066	.0885
.321	1704.5	817.8	281.03	4.206	.0206	.0057	.0819
.321	1931.8	794.8	279.55	3.802	.0193	.0049	.0753
.321	2159.1	772.4	278.09	3.450	.0180	.0042	.0691
.321	2386.4	750.7	276.64	3.121	.0166	.0036	.0631
.321	2613.6	729.5	275.18	2.792	.0153	.0031	.0572
.321	2840.9	709.0	273.73	2.463	.0141	.0025	.0516
.321	3068.2	689.0	272.27	2.171	.0129	.0021	.0465
.321	3295.5	669.6	270.79	1.966	.0118	.0018	.0422
.321	3522.7	650.8	269.31	1.761	.0108	.0015	.0383
.321	3750.0	632.4	267.84	1.556	.0100	.0013	.0349
.321	3977.3	614.6	266.36	1.351	.0093	.0010	.0320
.321	4204.5	597.3	264.88	1.213	.0087	.0009	.0299
.321	4431.8	580.5	263.40	1.082	.0084	.0007	.0285
.321	4659.1	564.1	261.93	.951	.0083	.0006	.0277
.321	4886.4	548.3	260.45	.820	.0084	.0005	.0276

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*
* TRANSMITTANCE RESULTS *
*

WAVELENGTH (MICRONS)	LINE ID	PATHLENGTH (KM)	OPTICAL DEPTH	TRANSMISSION
10.5910	CO2 P(20)	10.000	.6615	.5161

DESIGNATOR POSITION (X,Y,Z): .00 .00 .00 METERS

TARGET POSITION (X,Y,Z): 8660.00 .00 5000.00 METERS

MODEL ATMOS: PRESSURE: U.S.STANDARD EFFECTIVE SCALE HT: 7955.9 METERS
TEMPERATURE: U.S.STANDARD
H2O VAPOR PRESS: U.S.STANDARD

REFERENCE ALTITUDE (METERS): .0
REFERENCE PRESSURE (MB): 1013.3
REFERENCE TEMPERATURE (KELVIN): 292.11

----- ATMOSPHERIC LAYERS -----

PATH THRU LAYER (KM)	MIDLAYER ALTITUDE (M)	PRESSURE (MB)	TEMP (K)	H2O VAPOR (MB)	OPTICAL MOLECULAR ABSORPTN	DEPTH CONTINUUM H2O / N2	EXTINCTN COEFF (1/KM)
.455	113.6	998.9	291.37	7.572	.0371	.0195	.1245
.455	340.9	970.7	289.89	7.030	.0369	.0175	.1196
.455	568.2	943.4	288.42	6.487	.0362	.0155	.1138
.455	795.5	916.8	286.94	5.945	.0353	.0136	.1075
.455	1022.7	891.0	285.46	5.417	.0340	.0118	.1008
.455	1250.0	865.9	283.99	5.013	.0326	.0105	.0948
.455	1477.3	841.5	282.51	4.609	.0309	.0093	.0885
.455	1704.5	817.8	281.03	4.206	.0291	.0081	.0819
.455	1931.8	794.8	279.55	3.802	.0273	.0069	.0753
.455	2159.1	772.4	278.09	3.450	.0254	.0060	.0691
.455	2386.4	750.7	276.64	3.121	.0235	.0051	.0631
.455	2613.6	729.5	275.18	2.792	.0217	.0043	.0572
.455	2840.9	709.0	273.73	2.463	.0199	.0036	.0516
.455	3068.2	689.0	272.27	2.171	.0182	.0029	.0465
.455	3295.5	669.6	270.79	1.966	.0167	.0025	.0422
.455	3522.7	650.8	269.31	1.761	.0153	.0021	.0383
.455	3750.0	632.4	267.84	1.556	.0141	.0018	.0349
.455	3977.3	614.6	266.36	1.351	.0131	.0014	.0320
.455	4204.5	597.3	264.88	1.213	.0124	.0012	.0299
.455	4431.8	580.5	263.40	1.082	.0119	.0010	.0285
.455	4659.1	564.1	261.93	.951	.0117	.0009	.0277
.455	4886.4	548.3	260.45	.820	.0119	.0007	.0276

1

TOTAL TRANMITANCE FOR ALL SOURCES IS: .5161E+00

END EOSAEL RUN

1

2.4.3 Example 3

This example is similar to example 1 except it has been done for one of the new Ruby 0.694 laser lines.

Example 3 Input

WAVL	0.684	0.0000	0.0000	0.0000	0.0000	0.0000	0.00
LZTRAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TARG	2.0000	0.0000	0.2000	0.0	0.0	0.0	0.0
DESG	0.0000	0.0000	4.6000	0.0	0.0	0.0	0.0
ATMO	1013.2500	14.95	0.0000	6.0000	0.0000	0.0000	0.0
TEMP	6.0	0.0	0.0	0.0	0.0	0.0	0.0
PH2O	6.0	0.0	0.0	0.0	0.0	0.0	0.0
ALTL	6.0	0.0	0.0	0.0	0.0	0.0	0.0
GO	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ATMO	904.0000	20.85	1.0000	1.0000	0.0000	0.0000	0.0
TEMP	1.0	0.0	0.0	0.0	0.0	0.0	0.0

PH2O	1.0	0.0	0.0	0.0	0.0	0.0	0.0
ALTL	1.0	0.0	0.0	0.0	0.0	0.0	0.0
GO	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ATMO	804.0000	14.85	2.0000	1.0000	0.0000	0.0000	0.0
TEMP	1.0	0.0	0.0	0.0	0.0	0.0	0.0
PH2O	7.0	45.00	25.00	12.00	6.00	3.0	1.0
ALTL	1.0	0.0	0.0	0.0	0.0	0.0	0.0
DONE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
END	0.0	0.0	0.0	0.0	0.0	0.0	0.0
STOP	0.0	0.0	0.0	0.0	0.0	0.0	0.0

THE FOLLOWING IS EOSAEL SOURCE CONTROL INFORMATION YOU CAN SAFELY REMOVE IT
SCCS @(#) LZTRAN01.DAT 1.1 03/10/93

Example 3 Input

```
*****
WARNING - THIS LIBRARY CONTAINS TECHNICAL DATA WHOSE EXPORT IS RESTRICTED
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EXECUTIVE ORDER 12470. VIOLATION OF THESE EXPORT LAWS ARE SUBJECT TO
SEVERE CRIMINAL PENALTIES.
*****
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*****
*
*   ELECTRO-OPTICAL SYSTEMS   *
*
*   ATMOSPHERIC EFFECTS LIBRARY *
*
*   NOT FOR OPERATIONAL USE   *
*
* EOSAEL92 REV 1.1    03/10/93 *
*
*****
```

0

	BEGINNING	ENDING
WAVENUMBER (CM**-1)	14619.883	14619.883
WAVELENGTH (MICROMETERS)	.684	.684
FREQUENCY (GHZ)	438596.500	438596.500

**** EOSAEL WARNING ****
VISIBILITY AND EXTINCTION = 0.0, VISIBILITY CHANGED TO 10.0 KM

0

VISIBILITY

10.00 KM

```
*****
*                                     *
*               L Z T R A N          *
*                                     *
*      CALCULATE MOLECULAR          *
*      ABSORPTION COEFFICIENTS      *
*      AT SELECT LASER FREQUENCIES  *
*                                     *
*      EOSAEL92 REV 1.1   03/10/93  *
*                                     *
*****
```

***** WARNING *****
*** INPUT WAVELENGTH .684 CHANGED TO .693 NEAREST STANDARD WAVELENGTH ***

1

```
*****
*                                     *
*      TRANSMITTANCE RESULTS          *
*                                     *
*****
```

WAVELENGTH (MICRONS)	LINE ID	PATHLENGTH (KM)	OPTICAL DEPTH	TRANSMISSION
-----	-----	-----	-----	-----
.6930	MISC	4.833	.0160	.9841

DESIGNATOR POSITION (X,Y,Z): .00 .00 4600.00 METERS

TARGET POSITION (X,Y,Z): 2000.00 .00 200.00 METERS

MODEL ATMOS: PRESSURE: U.S.STANDARD EFFECTIVE SCALE HT: 7955.9 METERS
TEMPERATURE: U.S.STANDARD
H2O VAPOR PRESS: U.S.STANDARD

REFERENCE ALTITUDE (METERS): .0
REFERENCE PRESSURE (MB): 1013.3
REFERENCE TEMPERATURE (KELVIN): 288.11

----- ATMOSPHERIC LAYERS -----

PATH THRU LAYER (KM)	MIDLAYER ALTITUDE (M)	PRESSURE (MB)	TEMP (K)	H2O VAPOR (MB)	OPTICAL DEPTH MOLECULAR CONTINUUM ABSORPTN H2O / N2	EXTINCTN COEFF (1/KM)
----------------------------	-----------------------------	------------------	-------------	----------------------	---	-----------------------------

.269	4477.8	577.1	259.10	1.056	.0007	.0000	.0027
.269	4233.3	595.2	260.69	1.197	.0007	.0000	.0027
.269	3988.9	613.7	262.28	1.341	.0007	.0000	.0028
.269	3744.4	632.9	263.87	1.561	.0008	.0000	.0029
.269	3500.0	652.6	265.46	1.782	.0008	.0000	.0029
.269	3255.6	673.0	267.05	2.002	.0008	.0000	.0030
.269	3011.1	694.0	268.64	2.222	.0008	.0000	.0031
.269	2766.7	715.6	270.20	2.570	.0009	.0000	.0032
.269	2522.2	738.0	271.77	2.924	.0009	.0000	.0032
.269	2277.8	761.0	273.33	3.279	.0009	.0000	.0033
.269	2033.3	784.7	274.90	3.633	.0009	.0000	.0034
.269	1788.9	809.2	276.48	4.056	.0009	.0000	.0035
.269	1544.4	834.5	278.07	4.490	.0010	.0000	.0036
.269	1300.0	860.5	279.66	4.924	.0010	.0000	.0037
.269	1055.6	887.4	281.25	5.358	.0010	.0000	.0038
.269	811.1	915.0	282.84	5.908	.0010	.0000	.0039
.269	566.7	943.6	284.43	6.491	.0011	.0000	.0040
.269	322.2	973.0	286.02	7.074	.0011	.0000	.0041

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1

```

*****
*                                     *
*          TRANSMITTANCE RESULTS          *
*                                     *
*****

```

WAVELENGTH (MICRONS)	LINE ID	PATHLENGTH (KM)	OPTICAL DEPTH	TRANSMISSION
.6930	MISC	4.833	.0155	.9846

DESIGNATOR POSITION (X,Y,Z): .00 .00 4600.00 METERS

TARGET POSITION (X,Y,Z): 2000.00 .00 200.00 METERS

MODEL ATMOS: PRESSURE: TROPICAL EFFECTIVE SCALE HT: 8410.1 METERS
 TEMPERATURE: TROPICAL
 H2O VAPOR PRESS: TROPICAL

REFERENCE ALTITUDE (METERS): 1000.0
 REFERENCE PRESSURE (MB): 904.0
 REFERENCE TEMPERATURE (KELVIN): 294.01

----- ATMOSPHERIC LAYERS -----

PATH THRU LAYER (KM)	MIDLAYER ALTITUDE (M)	PRESSURE (MB)	TEMP (K)	H2O VAPOR (MB)	OPTICAL MOLECULAR ABSORPTN	DEPTH CONTINUUM H2O / N2	EXTINCTN COEFF (1/KM)
.269	4477.8	597.8	273.67	2.361	.0007	.0000	.0026
.269	4233.3	615.5	275.38	2.592	.0007	.0000	.0027
.269	3988.9	633.6	277.09	2.849	.0007	.0000	.0027
.269	3744.4	652.3	278.80	3.667	.0007	.0000	.0028
.269	3500.0	671.5	280.51	4.485	.0008	.0000	.0029

.269	3255.6	691.3	282.22	5.304	.0008	.0000	.0029
.269	3011.1	711.7	283.93	6.122	.0008	.0000	.0030
.269	2766.7	732.7	284.94	7.605	.0008	.0000	.0031
.269	2522.2	754.3	285.92	9.121	.0008	.0000	.0031
.269	2277.8	776.6	286.90	10.636	.0009	.0000	.0032
.269	2033.3	799.5	287.88	12.151	.0009	.0000	.0033
.269	1788.9	823.1	289.28	13.472	.0009	.0000	.0034
.269	1544.4	847.3	290.74	14.762	.0009	.0000	.0035
.269	1300.0	872.3	292.21	16.051	.0010	.0000	.0036
.269	1055.6	898.0	293.68	17.341	.0010	.0000	.0037
.269	811.1	924.5	295.14	19.271	.0010	.0000	.0037
.269	566.7	951.8	296.61	21.389	.0010	.0000	.0038
.269	322.2	979.9	298.08	23.507	.0011	.0000	.0039

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*** WARNING *** H2O VAPOR PRESSURE AT ALTITUDE 933.3 M IS GREATER THAN THE SATURATION PRESS. OF 25.24 MB.
 THE WATER VAPOR PRESS OF 26.33 MB IS RESET TO THE SATURATION VALUE.
 *** WARNING *** H2O VAPOR PRESSURE AT ALTITUDE 444.4 M IS GREATER THAN THE SATURATION PRESS. OF 30.16 MB.
 THE WATER VAPOR PRESS OF 36.11 MB IS RESET TO THE SATURATION VALUE.
 *** WARNING *** H2O VAPOR PRESSURE AT ALTITUDE 1055.6 M IS GREATER THAN THE SATURATION PRESS. OF 24.13 MB.
 THE WATER VAPOR PRESS OF 24.28 MB IS RESET TO THE SATURATION VALUE.
 *** WARNING *** H2O VAPOR PRESSURE AT ALTITUDE 811.1 M IS GREATER THAN THE SATURATION PRESS. OF 26.40 MB.
 THE WATER VAPOR PRESS OF 28.78 MB IS RESET TO THE SATURATION VALUE.
 *** WARNING *** H2O VAPOR PRESSURE AT ALTITUDE 566.7 M IS GREATER THAN THE SATURATION PRESS. OF 28.86 MB.
 THE WATER VAPOR PRESS OF 33.67 MB IS RESET TO THE SATURATION VALUE.
 *** WARNING *** H2O VAPOR PRESSURE AT ALTITUDE 322.2 M IS GREATER THAN THE SATURATION PRESS. OF 31.51 MB.
 THE WATER VAPOR PRESS OF 38.56 MB IS RESET TO THE SATURATION VALUE.

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*                                     *
*           TRANSMITTANCE RESULTS           *
*                                     *
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WAVELENGTH (MICRONS)	LINE ID	PATHLENGTH (KM)	OPTICAL DEPTH	TRANSMISSION
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.6930	MISC	4.833	.0156	.9845

DESIGNATOR POSITION (X,Y,Z): .00 .00 4600.00 METERS

TARGET POSITION (X,Y,Z): 2000.00 .00 200.00 METERS

MODEL ATMOS: PRESSURE: TROPICAL EFFECTIVE SCALE HT: 8410.1 METERS
 TEMPERATURE: TROPICAL
 H2O VAPOR PRESS: USER DEFINED

REFERENCE ALTITUDE (METERS): 2000.0
 REFERENCE PRESSURE (MB): 804.0
 REFERENCE TEMPERATURE (KELVIN): 288.01

----- ATMOSPHERIC LAYERS -----

PATH THRU LAYER (KM)	MIDLAYER ALTITUDE (M)	PRESSURE (MB)	TEMP (K)	H2O VAPOR (MB)	OPTICAL MOLECULAR ABSORPTN	DEPTH CONTINUUM H2O / N2	EXTINCTN COEFF (1/KM)
.269	4477.8	598.8	273.67	2.044	.0007	.0000	.0026
.269	4233.3	616.5	275.38	2.533	.0007	.0000	.0027
.269	3988.9	634.7	277.09	3.033	.0007	.0000	.0027
.269	3744.4	653.4	278.80	3.767	.0008	.0000	.0028
.269	3500.0	672.7	280.51	4.500	.0008	.0000	.0029
.269	3255.6	692.5	282.22	5.233	.0008	.0000	.0029
.269	3011.1	712.9	283.93	5.967	.0008	.0000	.0030
.269	2766.7	733.9	284.94	7.400	.0008	.0000	.0031
.269	2522.2	755.6	285.92	8.867	.0008	.0000	.0032
.269	2277.8	777.9	286.90	10.333	.0009	.0000	.0032
.269	2033.3	800.8	287.88	11.800	.0009	.0000	.0033
.269	1788.9	824.4	289.28	14.744	.0009	.0000	.0034
.269	1544.4	848.8	290.74	17.922	.0009	.0000	.0035
.269	1300.0	873.8	292.21	21.100	.0010	.0000	.0036
.269	1055.6	899.6	293.68	24.130	.0010	.0000	.0037
.269	811.1	926.1	295.14	26.402	.0010	.0000	.0037
.269	566.7	953.4	296.61	28.858	.0010	.0000	.0038
.269	322.2	981.5	298.08	31.512	.0011	.0000	.0039

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TOTAL TRANMITANCE FOR ALL SOURCES IS: .9845E+00

END EOSAEL RUN

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